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Application of the OCCO Filter for Noise Reduction in Bone Scan Images of Breast Cancer Patients

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The image quality of bone scintigraphy in Nuclear Medicine is often constrained by physical and technical factors, such as the inability to increase radiopharmaceutical activity or acquisition time beyond recommended levels. These limitations result in Poisson noise, characterized by random variations in pixel intensity that degrade spatial resolution. This noise can obscure clinically significant findings, especially small or low-contrast uptake areas, which are crucial for the accurate detection and monitoring of metastatic lesions in breast cancer patients [2].

The purpose of this work is to reduce Poisson noise in bone scan images of breast cancer patients by applying the Open-Close Close-Open (OCCO) morphological filter. The OCCO filter, based on mathematical morphology, is a processing technique that takes an original image I and a given structuring element B (usually a simple geometric shape, such as a disk or square) to sequentially apply two combined pairs of opening γ and closing φ: first, an opening followed by a closing, and then a closing followed by an opening. This process effectively removes unwanted details, reduces noise, and smooths minor irregularities while preserving relevant edges and structures. The OCCO filter is defined as follows [1]:

$$\text{OCCO}(I, B) = \frac{1}{2}\,\gamma(\varphi(I, B), B) + \frac{1}{2}\,\varphi(\gamma(I, B), B). \tag{1}$$

For the OCCO filter application, 582 bone scan images from 291 breast cancer patients attending the Nuclear Medicine service of IICS-UNA between 2020 and 2024 were used. In addition, each patient has a pair of images corresponding to the anterior and posterior projections. The images are in PNG (.png) format, have dimensions of 256 x 1024 pixels and are in 16-bit grayscale [3]. The OCCO filter was applied with square, disk and diamond structuring elements of sizes 1, 2 and 3. Therefore, the metrics applied for the evaluation of the filter in each analysis group were: SSIM, RMSE and PSNR. Four groups of images were analyzed, as shown in Figures 1 to 4: G1 corresponds to the anterior projection and G2 to the posterior projection of bone metastases, while G3 corresponds to the anterior projection and G4 to the posterior projection of no bone metastases. Therefore, the square structuring element of size 3 obtained the best results in 3 of the 4 groups, reaching an SSIM of 0.95 and PSNR of 40.83 in the best case, indicating higher structural similarity to the original image, better quality and lower reconstruction error.

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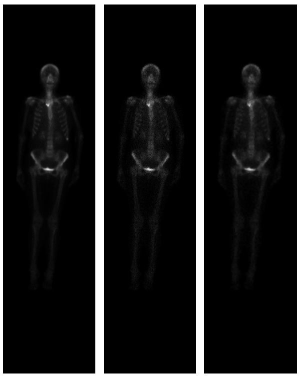

Figure 1: G1 (orig., noisy, filt.). Source: Author, 2024.

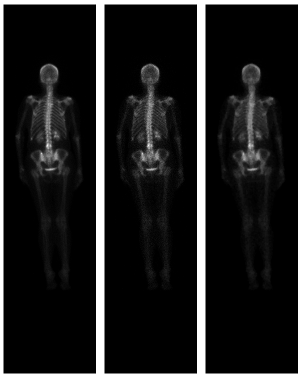

Figure 2: G2 (orig., noisy, filt.). Source: Author, 2024.

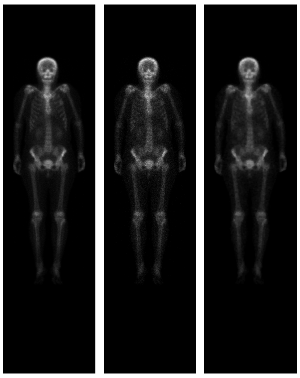

Figure 3: G3 (orig., noisy, filt.). Source: Author, 2024.

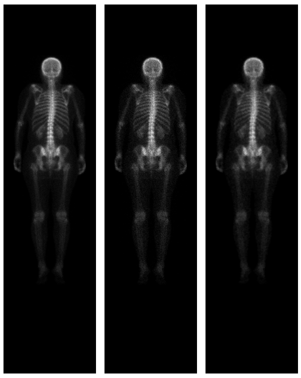

Figure 4: G4 (orig., noisy, filt.). Source: Author, 2024.

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